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PRESIDENTIAL ADDRESS,

OCTOBER 5TH, 1903.

THE MINERAL STRUCTURE OF SOME VICTORIAN ROCKS.

BY

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PRESIDENTIAL ADDRESS.

OCTOBER 5TH, 1903.

THE MINERAL STRUCTURE OF SOME VICTORIAN ROCKS.

BY JAMES STIRLING, A.I.C.E.

In 1896 I briefly referred to some of the results of recent research into the age and mineral contents of the geological formations represented in Victoria. Since that date a considerable amount of valuable information has been published, not only by the officers of the Geological survey on the different mining fields, but also by independent observers in the transactions of the Royal Society of Victoria. In one case a new formation has been suggested, to which the name Heathcotian has been applied.*

I cannot during the time now at my disposal review the whole of the valuable additions to our knowledge of Victorian geology and palæontology which has been published during the past seven years. I can only invite your attention to one branch of the subject briefly noticed in the address of 1896 (chiefly with reference to the work of Mr. A. W. Howitt), viz., the petrography of Victorian rocks. It is well known that petrographic research has not only given us a more definite scientific nomenclature for rock substances, but it has given an undoubted stimulus to the investigation of many difficult geological problems, and afforded a clue to the genesiology of metallic substances in the clearly-marked changes in the mineral components of the ore-bearing rocks which the microscopical examination reveals. I propose to outline the results of petrographic studies, carried out in spare moments during the past five years, and to briefly refer to several important papers bearing upon petrology which have been published during the past few years in Victoria.

* The Heathcotian, Prof. Gregory, Transactions Royal Society of Victoria.

The rocks examined by me may be classed as follows: (In the following remarks I have described the rocks according to their occurrence in the several localities examined.)

Authigenic Division.—SYENITE (granites) and GRANITITE: Wilson's Promontory, Cape Woolamai, Stawell, Maldon, Mt. Ararat, Elmhurst, Mt. Wills. PORPHYRIES: Mt. Cobboras, Mansfield district, Grampians, GRANOPHYRES: Elmhurst. APLITES: Tallandoon, Maldon, Elmhurst. EURITE: Mansfield district. QUARTZ PORPHYRIES: Stawell, Omeo, Grampians, Maldon. RHYOLITES: Little Tambo. PORPHYRITES: Omeo, Walhalla, Wentworth. DIORITES: Wood's Point, Walhalla, Omeo district. BOSTONITES: Omeo. LAMPROPHYRES: Omeo. VOGESITES: Heathcote. KERSANTITES: Walhalla. PICRITES: Walhalla. DIABASE: Elmhurst, Omeo. TESCHENITES: Cornobeas, South Gippsland. LIMBURGITES: Omeo, Maldon, Stawell, Coleraine. GABBRO: Cruikstown. DOLERITES: Watts, Johnstons, San Remo, Kilcunda, Korumburra, Meenyan, Gembrook, Yarragon, Neerim North, Jeetho. ANAMESITES and BASALTS: Jeetho, Phillip Island, Griffith's Point. OBSIDIAN: Coleraine. HORNBLENDE-SCHIST: Mt. Ararat.

Allogenic Division.—Clastic Rocks—TEPHRITES (conglomerates, grits, etc.): San Remo, Korumburra. PSAMITES (fine grits, sandstones): South Gippsland, Korumburra, Jumbunna, Kilcunda, San Remo, Walhalla, Mansfield, St. Kilda, Victorian Mt. Morgan mine. PELITES (shales, slates, etc.): Korumburra, San Remo, Walhalla. PHYTOGENES (carbonaceous shales, clod coal seam): South Gippsland from various localities. QUARTZITES: Tombullip (Mansfield district), Leongatha.

ROCKS OF THE COAL DISTRICT OF S. GIPPSLAND:—During the progress of the surveys of the coal-bearing areas in South Gippsland, samples of the sedimentary rocks of different localities were collected to illustrate the mineral composition of the beds, with a view to determine, if possible, their origin (or relation to the formations from which they were derived), and also samples of the eruptive rocks which have disturbed the coal-beds, in order to determine their mineral structure and probable age. The general mineral features of the eruptive rocks forming either dykes, bosses, or volcanic plugs from such localities as San Remo, Kilcunda, Bass Valley, Korumburra, Jumbunna, Meeniyan, Mirboo, Yarragon, Bena, Cruikstown, etc., suggest that they all belong to the GABBRO-BASALT family, and that they are of kainozoic age. Such differences in structure, or composition, as are met with at different localities, are to be ascribed to the differences in the rates of cooling and consolidation, rather than to any original differences in the

magma, or to the secondary effects of the action of the strata through which they have been erupted upon the invading magmas. It is also inferred that many of the broader masses termed dykes may prove to be either laccolites or volcanic plugs. The general effect of these igneous intrusions upon the coal beds is to indurate the coal seams in immediate proximity to the contacts, and to produce displacements. They do not appear to have brought about that extensive cindering of the coal seams, such as that produced by the intrusion of the dolerite masses into the permo-carboniferous beds of New South Wales and Queensland.

It has been pointed out that, in considering the history of a rock, it is necessary to bear in mind that two more or less distinct questions are involved.

(1) The origin of the minerals of which the rock is composed, and

(2) The origin of the rock itself. In some cases there is the most intimate connection between the origin of the rock and that of the minerals which enter into its composition. Thus igneous rocks have for the most part been formed by successive crystallisation of the constituent minerals from a molten magma. The minerals have been developed in situ (authigenic). In other cases, as, for instance, among sedimentary rocks, the origin of the rocks is for the most part wholly distinct from the rock, and have not been developed in situ (allogenic).

In the following descriptions of the microscopical examination of the Gippsland rocks, the eruptive rocks are included in the AUTHIGENIC division ; and the sedimentary —tephrites, psamites, and pelites, under the ALLOGENIC division.

In order to illustrate this work I commenced some years ago the publication of petrographic descriptions of the eruptive rocks as part of the work of the geological survey under the title of " Petrography of the Rocks of Victoria," with illustrative plates. Samples of the granite of Cape Woolamai and of a coarse-grained dyke at Cruikstown were selected for illustration. There appears to be a genetic relationship of the eruptive rocks of a geographical province (regarding them as varying phases of a process of differentiation from a common magma). I have, therefore, considered the differences in structure between the gabbros, dolerites, anamesites and basalts of this area, as depending upon the rates of cooling and consolidation. A description of the mineral components of a few of these eruptive rocks will suffice to illustrate their general character. In the dyke near Watts (Powong district) there is a rock resembling that forming the marginal portion of the Cruikstown

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gabbro previously described.* It consists of porphyritic olivines, well-formed broad-lath shaped labradorites, fine idiomorphic augites, and magnetite. The felspars penetrate the augite in places and show much polysenthetic twinning; the augites are also twinned, and a slight schillerisation is noticeable. Flecks of chlorite occur within the augite areas. In addition to the larger augite plates, there are smaller allotriomorphic grains, which, with smaller olivines, give to those parts of the slide where they occur a glomero-porphyritic structure. Some of the larger olivines show cleavages, and have a border of magnetite. There is much leucoxene after ilmenite. The rock is, therefore, an ophitic-olivine dolerite, approaching a gabbro in the coarseness of its structure.

Another example of this class of dykes may be given from Murray's allotment near Yarragon. This shows the ophitic structure very distinctly. The lath-shaped felspars are seen to form a mesh penetrating the broad plates of pyroxene, and large well-formed porphyritic olivines are distributed through the area of the slide. The labradorites show flow structure round the larger olivines, and contain inclusions of apatite, so that the order of consolidation is not difficult to trace; first the olivines, then the apatite, labradorite, and finally the augite. Magnetite occurs in grains of moderate size, and as fibres associated with ferric hydrate. Some of the olivines approach the variety hyalosideriete, in which faces parallel to ooP (110) show slight cleavage cracks parallel to the plane ooPoo, and irregular wavy cracks approximately parallel to 2Poo (021), the transverse cracks being filled with ferric hydrate. Crystals showing radially fibrous structure, probably chalcedony also occur. The rock is a porphyritic olivine dolerite.

Another, but finer grained dyke from the Bass Valley at Cornobeas presents some interesting petrographic characters which distinguish it from the majority of the eruptive rocks of the class I have described. In addition to numerous beautifully clear idiomorphic augites, labradorite, altered olivines and magnetite, there are crystals of the zeolite mineral known as analcite, formed between the felspars. There is also ilmenite weathering to leucoxene, some green chlorite and pseudomorphs after olivine. The rock approaches in mineral character and composition a teschenite, or an analcite diabase.

The variations in structure of different portions of the same dyke is very noticeable in some of the broader masses, where the marginal portions are much finer grained than

* Vide Petrography of the rocks of South Gippsland, 1899, Department of Mines.

the central. Such a case as that of Johnston's dyke, north-west of Korumburra, will serve to illustrate this. The central portion of the mass is an ophitic olivine dolerite, while the marginal is as follows:—Beautifully clear, well-formed crystals of felspar scattered through a ground mass of smaller felspars, with smaller pyroxene, olivine and magnetite. The larger felspars give labradorite extinction angles, they form either single individuals or form stellate groups. The smaller felspars in the ground mass approach bytownite. The olivines are but sparsely distributed. In addition to the lines of decomposition they have their surfaces covered with globulites, and sinuous curves of margarite, and also in places with peripheral wreath of magnetite. The marginal portion of the rock might be called either a porphyritic labradorite basalt or a porphyritic olivine anamesite.

Another example will suffice. In the south-east corner of Parsons' selection, Moyarra, there is a dense black dyke. This under the microscope shows a micro-crystalline ground mass, consisting of microliths of felspar, granules of augite and olivine and much magnetite, through which are scattered larger idiomorphic olivines and some augite. Many of the olivines are serpentenised, or show fibration along their margins. Some of the larger crystals are cleaved parallel to ∞P∞ (010). The magnetite occurs as single cubes or octahedra in parallel positions, and in some instances occupy the areas within the serpentenised olivines. This rock may be called a porphyritic-olivine basalt.

The effect which such dykes have upon the fine grained sandstone at contact is to cause a re-crystallisation of the felspathic materials of the latter. A sample sliced from the indurated rock forming the contact with the Cruikstown dyke showed the development of secondary felspar crystals. In the clastic rock, the sandstone contained in addition to the felspar grains some magnetite, a little chlorite, biotite and muscovite. In the brown areas which form the actual contact with the dyke the minerals are labradorite and augite, with a devitrified or glassy matrix. In the matrix are detached fragments of the sandstone. In some cases I have obtained a tachylitic rock, forming thin marginal crusts (fahlbands). These are probably the basalt-vitrophyres of Rosenbusch.

CLASTIC ROCKS.—The whole of the clastic rocks of the South Gippsland jurassic beds may be broadly divided into four classes, to which the terms tephrites, psamites, pelites and phytogenes may be applied.

The TEPHRITES include the conglomerates, agglomerates, and coarse grits; the PSAMITES the felspathic, arenaceous and slightly calcareous sandstones; the PELITES

the shales, mudstones and some kinds of clod or fine-grained, slightly carbonaceous shale.

The PHYTOGENES include the coal seams, and the highly carbonaceous shales. I have shewn illustrations of the several classes of rock from samples obtained by boring near Korumburra.* A few slices cut from these samples will serve to illustrate their mineral structure, and at the same time indicate the possibility of determining a lithological horizon for the coal seams from such information.

THE TEPHRITES.—In the sample marked No. 8, the slide is cut through one of the pebbles forming the conglomerate. The granitic structure is clearly seen; the felspars, orthoclase, albite and microperthite; the mica is biotite, with lenticles of calcite between the lamellæ, similar to the samples met with in the clastic rocks at San Remo, and which have evidently been derived from the wearing down of the Cape Woolamai granites. The whole aspect of the pebble shows its derivation from such plutonic rocks as those of Cape Woolamai. It is extremely probable, therefore, that the bed containing these pebbles may be found to extend towards the Woolamai plutonic area, and thus form a lithological horizon, which may be of value in determining the position of coal seams at Korumburra in relation to those at Kilcunda or Bass Valley. In others, the igneous fragments show a strong resemblance to the porphyrites and rhyolites.

PELITES.—These are merely finer grained varieties, in which the particles of felspar are highly comminuted. A sample from San Remo which was slightly calcareous gave very fine granular felspar with minute flecks of biotite, and some secondary muscovite, in a matrix of calcite (finely granular). In some places thin films of carbonaceous matter give to the rock a banded appearance and dark colour, with an increase in the amount of carbonaceous matter or a more highly comminuted argillaceous base, they pass over into the beds known as clod, or carbonaceous shale. Sometimes these shale beds alternate rapidly with the sandstones; in other cases they form thick deposits. They often, when exposed to atmospheric action, as in railway cuttings, decompose rapidly in concentric exfoliations, simulating the structures similarly produced by igneous rocks of the basaltic type when weathering.

PHYTOGENES.—Under this heading are included all the coal seams, and the carbonaceous shales. Many of the former are seen to consist of charred fragments. The microscopic examination shows in places the structure of coniferous trees, in others that of cycads.

WILSON'S PROMONTORY GRANITE.—The occurrence of

* Vide Quarterly Report of Mining Department.

stanniferous deposits near Toora has been known for a considerable time, and it was inferred that the source from which they had been derived was in all probability the Wilson's Promontory granites. With a view, therefore, to collect some data bearing on the question, and at the same time determine the mineral composition of the rocks of this important headland, I collected a few samples during a visit to Yanakie on the western side, and from the southern watershed of the Darby River on the eastern side. I had also in view the probability of determining the origin of some of the granitic pebbles forming portion of the conglomerate beds, met with in boring at Korumburra; and so fix a lithological horizon for the tephritic bands of the jurassic formation. The results showed—First, that portions of the granites are stanniferous; second, that the composition of these plutonic rocks is identical with that of many of the granitic pebbles met with in the Korumburra boring operations, and illustrated in the official reports. Another important question was, are these eruptive masses intrusive to the ordovician and silurian, or do they belong to an older palæozoic series of plutonic rocks? The evidence from the mineral structure and of the alteration of certain minerals clearly shows the effect of stresses upon the mass; in fact, of powerful dynamic action. And although there is very little, if any, evidence of contact metamorphism upon the sedimentary rocks near the line of contact in the Yanakie district; yet the occurrence of numerous small quartz veins in the latter, where outcropping to the north, near Shallow Inlet, is strongly suggestive of the influence of the eruptive rocks on the adjacent sedimentary formation. I will describe a few of the slices examined:—

No. 1 is composed of orthoclase, a little plagioclase; the felspars are very much sassuritised in places, and altered to beautiful flakes of secondary mica, sericite, rich brown biotites, and allotriomorphic quartz. Many of the biotites are altered to epidote and titano ferrite, and also contain garnets, apatite. The felspars are striated in places with limonite. The whole aspect of the slide suggests dynamic stresses.

In No. 2 the felspars are well developed, both orthoclase and plagioclase, the latter in idiomorphic forms, with much polysenthetic twinning, and correspond to oligoclase. Many of the larger felspars are altered to sericite. Some of them show zonal structure, and contain small areas of micro-pegmatite. Minute crystals resembling sodium fluo-silicate also occur within the felspar areas. The micas are principally rich brown biotites, full of apatites, garnets, zircons; in places they are very much altered to chlorite and epidote, and in some cases fringed

with minute rutile needles. The epidote occurs not only as a direct alteration from the biotite, but also in crystals showing rude, irregular cleavages parallel to oP (001) and ooPoo (100). These crystals are light olive-green to siskin green, under polarised light. The rock is essentially a granitite.

Another illustration of a sample from the Darby River district will suffice to indicate the effect of dynamic stress on the mass. The felspar crystals are fractured and broken irregular pieces of micro-perthite orthoclase and plagioclase, full of cracks, which have been filled in, either by fresh secondary felspar or quartz, the latter mineral having implanted itself upon the former, in more or less rounded outlines. Many of the crevices in the felspars are filled with a yellow mineral of finely granulated appearance, somewhat serpentenised. It also surrounds some of the quartz, etc. Many of the turbid felspars show stress laminae, similar to that which Forstner has produced in untwinned plagioclase by heating and cooling at various temperatures. The biotites, which are sparsely distributed, have undergone alteration to chlorite and epidote, and in one case to a bright yellow to brownish red decomposition product. The yellowish granulated matter may be a form of palagonite. Some of the large garnets are surrounded by fibrous chlorite, and in another there is a small radiating, bluish crystal, which I take to be kyanite.

In an interesting paper by Mr. E. G. Hogg, M.A., on the petrology of Victorian granites, published in the proceedings of the Royal Society of Victoria, Vol. XIII., page 12-224, a description given of the Gabo Island granite tallies very much with some of the Wilson's Promontory samples, but from the occurrence of hornblende it is classed among the syenites. So far as the samples examined from Wilson's Promontory may be taken as the basis for classification of the rock of the latter area, it is mainly a biotite granite, presenting many features in mineralogical composition with the Cape Woolamai granite, and may be contemporaneous in point of origin. The only reference to the Wilson's Promontory granites that I have seen are the very short notices in the descriptive catalogue of the Technical and Industrial Museum, pages 16 (172), as a common ternary granite from the shore of Corner Inlet, near Yanakie, rather coarse grained, with an indistinct banded structure, due to the arrangement of felspar and mica (the latter greatly preponderating), and several small garnets.

In the Descriptive Catalogue of Melbourne Centennial Exhibition, 1888, page 37, a sample from the lighthouse is described as a fine grained granite, containing a little plagio*clase felspar, and is* poor in mica.

A third slice from the Darby River shows beautiful large microperthites, within the areas of which there are biotites and allotriomorphic quartz, apatite. The biotite is in places altered to chlorite and epidote, also to muscovite. There is also some idiomorphic orthoclase. A fourth contains orthoclase, beautifully formed small rich brown biotites, microliths of apatite, with the areas of quartz between the biotites, garnets, tourmaline, chlorite. The aspect of this rock is that of a micro-granitite.

ERUPTIVE ROCKS OF THE OMEO DISTRICT.—Some years ago, I prepared for the Mining Department petrographic notes on the metamorphic rock and dyke stones of the Livingstone Valley, near Omeo. The minerals of these rocks were described principally from check notes, supplied to me by Mr. A. W. Howitt, whose researches among the plutonic and metamorphic rocks of the Australian Alps must form the basis for all subsequent detailed petrographic work. Since the date of the above report, I have made a close study of a considerable number of rock samples collected from time to time in the Mitta and Wentworth Valleys, with the result that I have been able to identify several varieties of eruptive rocks either not previously named by Mr. Howitt, or otherwise described in the papers already published by him (vide Inaugural Address of 1896). A few of these varieties may be referred to. Among the dykes radiating from Day's Hill, near Omeo, and classed as orthophyrs, there is one which I have identified as BOSTONITE with the following composition. A ground mass of minute orthoclase and magnetite grains, through which are scattered larger well formed crystals of orthoclase, which give to the mass a somewhat porphyritic appearance; part of the slide was stained by limonite. Another dyke crossing Day's Creek, which contains much biotite in irregular plates and flakes, fine porphyritic augites in clear, almost colourless, grains, with orthoclase and plagioclase occupying the interstices. Some of the former, with ferruginous stains, are probably ANORTHOCLASE. There is an abundance of magnetite, and some accessory hornblende, with occasional pseudomorphs of olivine. Numerous microlithic needles fill in the areas occupied by the felspars. The composition of this rock places it among the AUGITE, LAMPROPHYRES. A sample from Benambra Creek, near the Omeo Plains, may be classed as a pinite, bearing minette, or PINITE, LAMPROPHYRE. Although very much decomposed, it is seen to be composed of biotite, muscovite, chlorite, quartz, pinite after cordierite (spotted with enclosures of other minerals), and small grains of magnetite. To the north of Mt. Tambo there is a small conical hill known as Little Tambo, hitherto *recognised* as a felspar porphyry boss. The mineral struc-

ture of this rock places it among the porphyritic RHYOLITES. It consists of bright green and purplish pyroxene, corroded with large crystals, much magnetite and secondary iron ores, porphyritic orthoclase and plagioclase, and granular aggregates of quartz, in a ground mass of irregular grains of felspar and quartz.

Two samples of the rocks of the Cobberas Mountains, one from the summit, and the other from a spur forming the northern slope, were examined. That on the summit of the mountain was found to be a very distinct fluidal porphyry, consisting of a fluidal felsitic ground mass, in which are scattered partially corroded orthoclase and plagioclase felspars, beautifully clear idiomorphic quartz crystals, in places corroded, and some brown decomposition products. The rock on the northern spur is a SYENITE and contains abundant ortho-perthite in large shapely crystals. Within the areas of the latter are irregular pieces of green hornblende (altered in places to magnetite), and a little quartz. There are also some chloritised products after hornblende, and some limonite.* In the Wentworth River Valley, on the road between Dargo and Omeo, several dykes were examined. I may refer to a few of these. Near the head of Livingstone Creek, on the main Divide, there is a broad dyke of QUARTZ-MICA-DIORITE. It contains orthoclase and brightly polarising plagioclase, biotite, showing alterations to chlorite, traces of greenish hornblende, some secondary magnetite, and apatite. On the Omeo to Dargo road, near Wild Horse Creek, a mass of conglomerate outcrops; close to this, there is an outcrop of eruptive rock, which consists of a micro-crystalline ground mass, in which are amphibole, augite in less amount, and magnetite, with plagioclase in large crystals, much altered. The hornblende includes augite crystals, much altered. It is therefore a dyke of the HORNBLENDE PORPHYRITE class. In the same locality, there is another dyke of similar composition, except that the felspars are more numerous, and the bisilicates are converted to chlorite (it adjoins the quartz conglomerate on the north). Near Jones, on the Wentworth crossing, there is a dyke consisting of a micro-crystalline ground mass of minute ragged felspars, flakes and stout fibres of chlorite, biotite, much magnetite. There are also numerous flakes of chlorite in the plagioclase felspars of the ground mass. In the Tucker Creek valley (near a mining claim) a well formed dyke outcrops. It consists of large

* These determinations confirm the original observations of Howitt in his masterly "Notes on the Devonian Rocks of North Gippsland," that the Cobberas Mountains are plugs of ancient volcanoes surrounded *by the consolidated* ash and tufa beds now forming banded and *fragmental porphyries.*

imperfectly formed fibrous amphibole, in a ground mass of small plagioclase and amphibole prisms, with magnetite, in the plagioclases. It may also be classed as an HORNBLENDE PORPHYRITE.

Among the basic dykes of the Livingstone Creek valley, there are several which have been hitherto classed as diabase. One of these crossing Day's Creek may be referred to. It is a fine grained rock, consisting of porphyritic olivines (which are in parts calcified), and full of small grains of magnetite; in a micro-crystalline matrix of very fine, small augites, plagioclase felspar, and abundant grains of magnetite. There are also a number of small calcite patches. The rock is an OLIVINE ANAMESITE. Another, on Wilson's Creek (35b), is an altered OLIVINE BASALT. It consists of a ground mass of augite and magnetite, with olivines (converted into serpentenised pseudomorphs), in a network of plagioclase felspar.

I have elsewhere shown that there is a direct relation between the genesis of certain classes of quartz veins and some of the eruptive rocks of the Omeo district; that these quartz veins, which are auriferous, are associated with certain dykes of the diorite class. I have no doubt that a complete petrographic examination of all the eruptive rocks of the Livingstone Creek valley would disclose the sources of the auriferous materials in the alluvial deposits.

ERUPTIVE ROCKS OF THE WESTERN DISTRICT.—The rocks of an area to the east of the Sierra range, in the vicinity of the Mt. William Goldfield, have been described in a report by Mr. Herman, published in 1900. The eruptive rocks, with which the auriferous quartz veins are associated, have, on the authority of Mr. Howitt (who examined the specimens submitted to him by Mr. Herman), been described as QUARTZ-MICA-DIORITES. I had, prior to Mr. Herman's report, already referred to the eruptive rocks of similar character at the Stony Creek Goldfield, to members of the diorite class, and had suggested that these rocks, together with certain felspar porphyrites, might be intrusive into the Grampians sandstone. The examination of several slices from the contact of the porphyries of the Victoria Valley, with the overlying sandstones, which show dynamo-metamorphic action, suggest the possibility of such contact metamorphism in the case of the felspar porphyries being due in many cases to the pressure of the overlying sandstones upon the older plutonic rocks, rather than to the effects of the intrusion of the latter into the sandstones. The views expressed by Mr. Herman as to the derivation of the auriferous materials from the degradation of the small quartz veins intersecting the diorites are in harmony with the re-

marks previously made by me in the brief note on the Stony Creek deposits.

During a hurried examination of the area to the south and south-west of the Grampians, made some years ago,* I collected a few samples of the eruptive rocks. These, together with a number of samples collected by Mr. Ferguson from the Coleraine district, will now be described. A more detailed field survey is required, however, before the genetic relationships can receive adequate discussion. In the meantime, the petrographic descriptions may prove useful to students of geology.

Slice No. 5 is interesting as containing NEPHELINE. It is composed of long lath-shaped felspars, green augite (not dichroic), irregular masses enclosed between the felspar, much fresh nepheline in small rectangular prisms. There are also several large porphyritic sanidines. This rock may be classed among the PHENOLITES, which are allied to the trachytes, or as a TRACHY-PHONOLITE.

In his notes on the igneous rocks of South-Western Victoria (Trans. Aust. Association for Advancement of Science, 1893), Mr. Denant refers to the rocks known as Adam and Eve, near Coleraine, as consisting of lava. A section prepared from a sample collected by Mr. Ferguson gave mineral components, which place it among the LIMBURGITES. It consists of a micro-crystalline base of augite, grains of olivine, and magnetite, with glassy matter, through which are scattered larger crystals of colourless and brown augite, and porphyritic olivines. In part of the slice the magnetite occurs in clusters. It appears to be distinct from the trachytic rocks of the locality, and is probably a dyke or boss. Mr. Denant also refers to certain rocks of vivid green colour, and somewhat fissile, which occur at the Hummocks, to the north of Casterton, as of volcanic origin. A slice of this rock examined by me gave serpentenised olivine, altered pyroxene, altered triclinic felspar, and magnetite in irregular streaks and granules. The original mineral composition and structure of this rock would place it among the gabbro or DOLERITE class.

In an interesting paper on the occurrence of trachyte in Victoria, published in the transactions of the Royal Society of Victoria (Vol. XII., pages 91, 99), by Mr. E. G. Hogg, M.A., reference is made to the two conical hills known as Adam and Eve, as consisting of olivine basalt, and he describes a dyke running through one of them as trachyte, consisting of an orthophyric ground mass, with phenocrysta of sanidine and some accessory apatite. A slice of this rock examined by me gave a very distinct felsitic trachytic ground

* *Report on the Mining* and Geological features of portion of the *Western District.—Progress* Report Geological Survey.

mass, and numerous clear, glassy sanidines showing cleavages on faces=76 deg.

At Gano Gano (E. 28), Glenelg, Mr. Ferguson collected a peculiar schistose rock. Under the microscope it is seen to consist of hornblende, felspar and quartz. The hornblende shows considerable alteration to diallage, and as elongated broken crystals of brownish tints. In places altered to chlorite or epidote, and contains apatite. Quartz fills in the areas between the irregular mass of hornblende and felspar; some of the latter contain microlitic inclusions, and are fractured and broken. The structure of this rock shows alteration from an eruptive rock of the diorite class resembling in this respect the alteration of dolerite into hornblende schist, as described by Teall, in Q.J.G.S.

In a paper (Transactions of the Royal Society of Victoria, 1901) entitled "Further Notes on the Igneous Rocks of South-Western Victoria," Mr. Denant describes a rock from Phoines as a TRACHYTE, containing sanidine, with an abundance of brown and very little green augite. A sample collected from Phoines by Mr. Ferguson gave slightly different mineral characters, viz., a micro-felsitic (somewhat lithoidal) ground mass of monoclinic felspar, flecks and grains of ferrite and magnetite, through which are scattered crystals of clear idiomorphic orthoclase of the var. sanidine. In places the felspar is very much altered (kaolinised); numerous flakes of biotite occur in the ground mass. There are also some garnets. The felspars gave faces parallel to M(∞P∞) and base oP (001). It is certainly a TRACHYTE. Among several of the rock slices examined by me from the Grampians district, I may refer to the following:—Schistose rocks, Turkey Bottom Creek, collected by Mr. Ferguson. This is composed mainly of quartz and felspar grains or granules, with much brown mica, containing inclusions. Another sample from Boundary Creek, Wando (marked mica schist), contains granules of quartz, felspar, and flakes of mica (both muscovite and biotite). (E. 33.) Among plutonic rocks, there are several interesting samples, one is a syenite, containing allotrio-morphic quartz, orthoclase, albite, biotite, magnetite, greenish hornblende, and chloritised mica.

(E. 48) Is a SYENITE containing turbid orthoclase felspar, flecks of muscovite, hornblende, actinolite, and quartz. Another sample (203) contains allotriomorphic quartz grains, large turbid felspars, flakes of green hornblende partially discoloured by ferric oxide, minute apatites and zircons. The felspars, both orthoclase and plagioclase, are broken and seamed with limonite.

Near Balmoral, a sample gave idiomorphic triclinic felspar (albite), muscovite, hornblende, quartz, some of the

felspars showing zonal structure. (D. 106.) Rocks of the ORTHOPHYR class also occur. A sample from Coleraine gave a felsitic base of idiomorphic orthoclase, with allotriomorphic grains of augite, magnetite. This is evidently part of the rock mass described by Mr. Hogg as trachyte.* Another slice examined from this district consisted of microliths of amphibole scattered through a crypto-crystalline base of felspar, with granules of ferrite and magnetite. Several varieties of porphyries and felsitic rocks were also examined. Among these I may mention the following:—

No. 161, at Rocklands. This, in hand specimens, resembles a fine-grained flextured sandstone, of Archaen age. Under the microscope, it is seen to consist of fibro-granular felspathic ground mass, through which are scattered somewhat turbid idiomorphic orthoclase, with secondary quartz along the foliations; portions of the felspar ground mass is altered to ferric hydrate or limonite. There is evidence of considerable alteration of the original felspar into finely granular aggregates. It has all the appearance of a highly altered eruptive rock of the BOSTONITE class; it may be best described as a banded FELSITE. Another sample consists of a micro-crystalline ground mass of brown turbid felspar, allotriomorphic quartz, plates of mica, magnetite and ferrite (some of the felspars are altered to sericite mica), while another contains allotriomorphic felspars, micro-perthite and crypto-perthite, altered in places to a micro-pegmatitic structure. There is also biotite, hypidiomorphic quartz, and a partial liquidation of the felspars. It may be called a micro-granite, or QUARTZ FELSITE.

A slice of cherry porphyry shows that this rock has an almost hyalophilitic structure, occasional quartz granules, ferrite. It is a PORPHYRY approaching a FELSOPHYRE. The rock is from the contact with the Grampians sandstone. Another slice from the same locality showed a more clastic structure, consisting of sub-angular grains of felspar and quartz, bands of magnetite and quartz, evidently a metamorphosed shale. A beautiful example of the structure produced by dynamo-metamorphic action was collected from the contact of the sandstones of the Victoria Valley, with the underlying porphyritic rocks. It consists of a crypto-crystalline granular base, scattered beautifully clear felspar crystals (fractured and broken), secondary quartz. Some of the felspars are altered to secondary mica, magnetite. It is a banded FELSPAR PORPHYRY, with occasional quartz crystals.

Another banded porphyry was examined. It consists of allotriomorphic felspar, idiomorphic quartz, corroded by in-

* *Transactions Royal* Society of Victoria, Vol. II., pp. 97, 98.

clusions of the ground mass. There is also much plagioclase showing multiple twinning, small augites, surrounded by a mosaic of quartz grains, and magnetite associated with the pyroxenes.

A slice obtained in the Victoria Range, Grampians, at the contact of the porphyry with the sandstones, shows very distinctly the effect of dynamo-metamorphic action, due to the pressure of the overlying sandstones upon the eruptive rocks of the locality. It consists of a micro-spherulitic and partly axiolitic ground mass, between phenocrysts of felspar and quartz. The interspaces between the spherulites are filled with irregular grains of greenish pyroxene or chlorite and allotriomorphic felspar. The phenocrysts of felspar are very much altered to secondary mica or kaolin, showing in places a micro-poecilitic structure, and have reaction rims. The quartz crystals are corroded by the ground mass; magnetite and apatite also occur. Although the rock has a somewhat rhyolitic appearance, it may be classed among the FELSPAR PORPHYRIES.

ROCKS OF THE WALHALLA GOLDFIELD.—During the geological and underground survey of the mines at Walhalla, samples of the silurian sedimentary rocks and also of several eruptive rocks were collected by my son, the late V. R. Stirling. Owing to the decomposition of the original minerals and the infiltration of secondary constituents, it was difficult to classify some of the samples. Notwithstanding this, it has been possible to arrive at some general conclusions which may have an important bearing on the genesis of the auriferous lodes of the district, which has long been famous for the persistency of the auriferous veins associated with the eruptive rocks of the area. A hypabyssal as opposed to a plutonic origin for the igneous rocks seems conclusively demonstrated by their structure, and the perfect idiomorphism of the better preserved felspars. Their originally basic nature is shown by the character of the felspars and of the decomposition products. Where quartz is abundant there is every reason to believe that it is of secondary origin. It seems to have been deposited by percolating water. The decomposition was probably due to causes connected with the process of silification. Hydro-thermal action would readily effect such results, and at the same time account for the mineralisation of the surrounding rocks.

It has been pointed out * that in the case of volcanic rocks the alteration would naturally be attended by the deposition of silicious sinter. In such an instance as the one under consideration, where the rocks were intrusive, and were in all probability considerably removed from the

* *Teall's* British Petrography, p. 412.

surface of the ground at the time that they were intruded, no such deposit can be looked for in the immediate vicinity of the lodes. The character of the vein quartz, however, agrees very well with the idea that it might have been deposited from solution in thermal waters, which may or may not have risen to the surface.

The sedimentary country rocks do not seem, in most cases, to have been appreciably affected by contact metamorphism, though one or two of the specimens which have been omitted from the descriptions on account of their advanced state of decomposition may possibly be referable to rocks of the "hornfels" type.* This comparative absence of alteration by heat may be taken as an indication that the dykes never rose to the surface, and were consequently unconnected with any volcanic vent through which eruptions may have taken place.

Professor Judd has drawn attention to the fact that the extent of alteration by contact is chiefly determined in this way, so that comparatively small dykes, in which a constant flow was kept up to supply material erupted at the surface, might, and probably would effect great changes in the surrounding rocks, while others of much greater extent which cooled down immediately after their injection, might not give rise to any noticeable alteration. The silurian slates and sandstones are frequently intersected by small veins of quartz. These do not fill cracks due to mere expansion and contraction. They are, as in the case of the Bendigo rocks,† intimately connected with the processes of metamorphism, and in the case of the Walhalla rocks, have evidently been infiltrated along planes of shearing—faults on a small scale—as evidenced by the phyllitic or schistose character of the rocks along the sides of a vein. Such alteration is nearly always evident under the microscope, though it may not extend to more than a few millimetres.

In an appendix to Mr. Herman's report on the Walhalla goldfield‡ (the survey of which was organised by me some years ago, but the manuscript of which was never seen by me until published), there are some valuable petrographic descriptions of certain rocks from the Walhalla district. Several of the samples examined by Mr. Howitt appear to be from the same localities as those examined by me, and with the exception of a slight difference in the names given to some of the eruptive rocks, the general descriptions of the mineral components are in accord. Mr. Herman has

* The terms hornfels and hornstones for rocks which have undergone thermal metamorphism is now very little used by British petrographers.

† "Notes on the Rocks of 180 Mine, Bendigo," by A. W. Howitt.

‡ Report on Walhalla Goldfield, with plans, plates and sections.—*Department of Mines*, 1901.

also, under the headings Metamorphism, Dykes in Silurian, Quartz Occurrences, at pages 18-20 of report, and in Summary of Geological History, pages 25-26, given an excellent resume of the bearing which some of the petrographic investigations of Mr. Howitt have upon the genesis of the auriferous quartz veins.

It would be possible to throw a further light on the subject and also to still further amplify the remarks made in the light of my own petrographic work, but as this would extend this matter to too great a length, I must defer its further consideration for another opportunity. In the meantime, as my work has not been published by the Mining Department, I submit the following descriptions of the rocks examined, for the information of the members of the Geological Society. The rocks may be broadly divided into two classes, viz., clastic or sedimentary rock and eruptive or igneous rock. The examinations of the former show that they belong to the division of shales (locally known as slates) and sandstone, and in places where the latter has been crushed by earth stresses, a structure has been produced to which the term MYLONITE may be applied. Hitherto the term DIORITE has been applied almost indiscriminately to the eruptive rocks of the district, especially those with which auriferous quartz veins are associated, and I now propose a more definite classification for the rocks examined in accordance with their mineral structure.

CLASTIC ROCKS—A. PELITES.—A typical specimen of this class is presented in an example of slate with quartz vein from the Long Tunnel mine, 1,722 feet level. This specimen shows admirably the infiltration of quartz along a plane of slipping. The movement has induced a phyllitic modification of the slate, which is evident on each side of the vein by which it is traversed. Minute crystals of pyrites are abundant in the slate, and they are in most cases enveloped by little patches of radially fibrous chalcedony. The vein quartz is full of cavities, containing fluid inclusions in many cases. They are so crowded together as to give the quartz a cloudy appearance.

Another slate specimen from the Long Tunnel Extended mine is of the upper silurian country rock. The slice was cut from a part which exhibits a remarkable bend, or contortion, and it is interesting to notice the incipient production of lenticles under the stress. The folding has evidently been brought about by pressure acting parallel to the bedding, so that the long axes of the lenticles are in a direction approximately at right angles to it. A more satisfactory example of the structure being developed in a direction differing widely from the original stratification could not be *wished for*, as the bedding is clearly indicated by alternating

light and dark bands, which are distinctly visible under the microscope.

B. PSAMITES. — An example of sandstone is from a bed 2½ feet thick, in the cutting along the main road near Warne's water wheel. This is a coarse-grained mechanical sediment of the ordinary compact type, composed of quartz grains without much cementing material, the interspaces being filled with smaller quartz granules. A few grains of clastic felspar may be detected by the aid of convergent polarised light, and some minute tourmaline grains.

Sandstone from a lenticular patch in the slate. From the footwall of the reef, in the stope above the 1,800 feet level, at the south end of the Long Tunnel Extended mine, I obtained a very fine-grained sandstone, constituting nothing more than a coarser modification of the shale in which it occurs. From the latter it is differentiated under the microscope by the fact that the individual grains, though small, are readily identified by their optical characters as quartz. The specimen is traversed by veinlets of secondary quartz, and shows a junction with the slate, which exhibits the usual phyllitic modification where it is traversed by one of the veins. This shows that the quartz, as in the other cases, was infiltrated along a line of movement in the rock, due to shearing. Pyrites and small rounded crystals of zircon and tourmaline were also observed.

A specimen was also taken from a drive close to the end of the long crosscut in the tunnel above the Longfellow's battery. The characters of this rock are much obscured by infiltrated calcite, a highly schistose appearance being its most obvious feature. A close examination reveals the fact that what are almost certainly clastic grains of quartz derived from a sandstone are mingled with materials of igneous origin. A certain amount of sericitic mica has been produced along planes parallel to movement in the rock, which must be regarded as of cataclastic origin, i.e., a fault rock, formed by the grinding up of pre-existing masses along a line of fracture. It may indicate the junction of a dyke with the sedimentary rocks, as faulting frequently takes place along such a boundary. To the rock the more or less indefinite term MYLONITE is the only one that can be applied. Mr. Howitt considers the slice he examined from same locality to be a good example of the effect of a form of dynamo-metamorphism upon some quartzitic sandstones.

ERUPTIVE ROCKS. — Marked Siliceous Dyke with Pyrites.—From the short drive halfway along the long crosscut in the eastern gully, Longfellow's Gold Mining Co.'s mine, I obtained an example of the above. Though *much decomposed*, the felspars are comparatively fresh.

The crystals are tabular, being elongated in the direction of the basal plane (o.P.), as is usual in such cases, and their outlines remain fairly well defined. The brachypinacoidal faces are particularly well developed. Polysynthetic twinning is usually shown, though the lamellae are not generally numerous, and are sometimes very impersistent. The extinction angle measured to the twinning plane varies, in sections which give fairly symmetrical results, from 15 to about 18, so that the mineral approaches labradorite, indicating that the rock is either basic, or sub-basic in character. This indication is confirmed by the nature of the decomposition products, which make up a large proportion of the rock. Secondary quartz is abundant, but it is subordinate on the whole to calcite, while brilliantly polarising epidote is also of frequent occurrence, probably altered biotite. The presence of a ferro-magnesian mineral in some abundance may be inferred from the character of the alteration products. One of the calcite grains seems to be distinctly pseudomorphous after a pyroxenic mineral (augite), showing not only some approach to the crystalline form of the original mineral, but even affording some indication of the characteristic cleavage. It contains pyrites, magnetite, and minute apatites. The original rock was probably an AUGITE-MICA-PORPHYRITE.

Mr. Howitt has apparently classed this a rock among the quartz-mica-diorites, and considers the felspar andesine. He states it contains bleached biotite and small apatite prisms. also pyrites and magnetite.

Another slice was obtained from one dyke at the north face of crosscut No. 6, Great South Long Tunnel Company's mine. Though very much decomposed, this rock is evidently of igneous origin. It contains felspar (plagioclase) in a recognisable condition, either andesite or labradorite, but the ferro-magnesian minerals which must have been present have been entirely replaced by calcite and dolomite, with some epidote and quartz. If the space now taken up by the various decomposition products was originally entirely occupied by the ferro-magnesian constituents, the rock must have been of a very basic nature. In general character, however, it strongly resembles specimen 10 (see above), so that it must be presumed that the calcite represents some of the felspar as well as augite or hornblende, i.e., it is probably an altered augite or HORNBLENDE MICA-PORPHYRITE. A. W. Howitt considers this rock to be a much altered quartz-mica-diorite, or somewhat fine-grained QUARTZ-MICA-HORNBLENDE diorite, and infers that the "alterations are connected with the formation of the lodes and with alteration and deposition of the metallic ore." *With this* view as to the alteration processes and its *effects I entirely* agree.

The dyke rock in the Long Tunnel Extended mine yielded a specimen in which mica is the most conspicuous mineral. It occurs in large flakes, set at all angles in the mass, and shows the bleaching and fraying out so characteristic of biotite which has undergone a certain amount of alteration. Under a high power minute lenticular patches of calcite and quartz, and little rhombohedral crystals of dolomite may be seen to have formed between the cleavage flakes of the mineral. Its optical character between crossed nicols is, however, little affected. The crystals give the usual straight extinction, and the interference tints are those of the second order. The other minerals which originally constituted the rock are in a very much more decomposed state than the biotite. Granular felspar and large grains of quartz, which may be in part original, are to be observed, but the bulk of the ground mass has had its characters almost entirely obliterated by the development of the indefinite aggregates of epidote, calcite, and other secondary products. Pyrites is also abundant in the form of arsenopyrite or needle pyrites.

Taking all the features of the rock and its decomposition products into consideration, there can be little doubt that it belongs to the class to which Rosenbuch has applied Von Gumbel's name of LAMPROPHYRE. The necessity for a separate division for rocks of this nature is not, however, very obvious, and the name MICA PORPHYRITE seems very well adapted for the expression of its characters and relationships, though if the more cumbrous system of nomenclature be preferred, the name of KERSANTITE would be the one to use.

DIORITE.—From a large boulder on the right hand branch of Stringer's Creek, I obtained a specimen of diorite. In contrast to many of the others, this rock is in a very fresh condition, the only constituent which shows any sign of decomposition being the felspar. The bulk of the rock is made up of brown hornblende. The crystals, which show the characteristic acute-angled prismatic cleavage, and give a maximum extinction angle of about 24 deg. in longitudinal sections, are so large in many cases that they fill the field of the microscope even when the lowest powers are used. They are mostly allotriomorphic, but occasionally present crystal faces prism and clino-pinacoid to the felspar. The latter is quite subordinate to the hornblende. It is somewhat opaque, and shows no signs of twinning, lamellar or otherwise, but the cleavages are well developed, and the extinction angles denote that it is a very basic variety. There are a few granules of ilmenite decomposing to leucoxene. A little devitrifying glass appears to occur interstitially between the other constituents. The most remarkable feature

of the rock is the fact that both the hornblende and the feispars enclose in poecilitic fashion numerous well developed crystals of augite, and also apparently enstatite. The latter show interference tints, which do not exceed the yellow of the first order. Like the augite, they are quite transparent, and do not show any signs of pleochroism. From the perfectly idiomorphic contours of these two minerals and the entire absence of any signs of alteration, it seems certain that all the ferro-magnesian minerals of which the three chief types are represented, are to be regarded as primary constituents of the rock. The hornblende is of the brown variety, which is almost without exception original. If the section examined is typical of the whole of the rock, it should be placed in the ultra basic series, and among the HORNBLENDE PICRITES. Howitt does not appear to have named this rock, but merely refers to the occurrence of a rhombic pyroxene, and suggests that the felspars belong to the labradorites. I have given these detailed petrographic descriptions of the Walhalla rocks because I believe that there is an intimate connection between the agencies at work in the decomposition of the surrounding rocks, and the decomposition of the metallic minerals in the lodes and country rock.

WOOD'S POINT DIORITE.—The quartz veins intersecting the dykes of the Wood's Point district have in many instances proved to be highly auriferous. A thorough petrographic examination of the eruptive rocks and the adjacent sedimentary formations would undoubtedly yield important data bearing upon auro-genesis in this district. In order to arrive at definite information respecting the mineral structure of the dykes, and its correct nomenclature, samples were obtained from the Morning Star dyke, where pierced by diamond drill bore. About thirty slices were examined from different depths. The preponderating mineral was found to be amphibole, of the species hornblende, and its alteration product chlorite, and associated with two kinds of felspar, orthoclase and plagioclase, the latter predominating, although in many cases very much weathered. Quartz occurs in nearly all the slices. In many cases a micropegmatitic structure is observed. The iron ores in the form of ilmenite and its alteration product leucoxene are well distributed. Accessory minerals—zircon, emery, apatite, pyrites, and epidote—also occur.

Some of the samples, if taken singly as the basis of classification, would bring the rock under the class of hornblende porphyrites (within the hypa-byssal group of eruptives*). The general absence of any glassy ground mass, and almost invariable occurrence of quartz (in many cases

* *Trans.* British Association of Science, Glasgow meeting.

of primary character) brings the whole of the dyke within the quartz diorite class, although there is considerable affinity with the syenites. The occurrence of the contact mineral cordierite has been noted by Mr. J. P. Mennell in some portions of rock. I have not been able to identify this mineral in any of the slices I have examined. The general mineral structure of the dyke may be illustrated by a few examples, as follows:—Slice No. 259—Much decomposed. Little quartz, still fresh plagioclase, hornblende, weathered in parts with production of thin scaly mica, limonite, some beautiful blue grains of emery.* No. 2—Plagioclase, orthoclase, and quartz hornblende, weathered to chlorite and stained with limonite, pyrites, weathered to ilmenite, apatite, emery grains and some biotite. No. 3—Fine rich green and brown idiomorphic hornblendes, numerous basal sections, felspars in places much sassuritised. A micro-pegmatitic structure in parts. Some of the hornblendes present a diallogic appearance in places; crystals of titano ferrite, ilmenite. No. 4—Rich brown hypidiomorphic hornblendes, either singly or in groups, weathering into pale green almost colourless hornblendes, and a fibrous little green primary hornblende on surface of brown, some chlorite partly idiomorphic, ilmenite weathered to leucoxene, pyrite, calcite, and epidote; there is a considerable amount of orthoclase felspar ribbed with chlorite, epidote. No. 5—Idiomorphic brown hornblendes, secondary pale coloured augite, weathering to colourless hornblende or tremolite. Greenish hornblende often deposits on ends of brown slightly ophitic structure; much orthoclase, plagioclase, a little quartz, good deal of chlorite and calcite, ilmenite, ferrite and a little biotite. No. 6—Fine clear idiomorphic hornblende, included felspars forming an ophitic structure. Felspars highly weathered; some quartz, a little micro-pegmatite, pyrites and iron oxides, sheets of calcite, zircon, chlorite highly coloured, giving indigo blue polarisation colours. The foregoing examples are sufficient to illustrate the slight differences in mineral structure in various parts of the dyke. Unfortunately no slices of the sedimentary rocks at contact are available to determine the character of the effect which the dyke mass has had upon the former.

The term PROPYLITE has been used elsewhere to express certain microscopical appearances and chemical changes, which appear to distinguish certain members of the diorite or porphyritic diorite group, especially those with a large amount of chlorite, which has in many cases been taken for a kind of green hornblende. Later observations by Becker,

* *It is quite possible* that the emery grains are accidental—portions *of the abrading material* used in the preparation of the slide.

of the United States Geological Survey, have shown that the use of this term as a distinctive one is no longer admissable, so far as the class of rocks to which it was originally applied is concerned. And he goes so far as to say that the term PROPYLITE for the pre-Andesitic tertiary rocks of the United States should "not be retained in the nomenclature of American geology, even to express certain results of decomposition" (page 376 of Report on Geology of Comstock Lode).

I had already, from the examination of a few slides, described the Wood's Point diorite as an hornblende porphyrite,* but the more detailed examination now made enables me to place it among the QUARTZ DIORITE class.

The geological surveys of the Wood's Point district now being carried on by Mr. O. A. T. Whitelaw, should yield valuable data for determining the relations of the various eruptive dykes of this interesting area.

Another slide examined from this district, No. 199, gave a little quartz and much micro-pegmatite, considerable amount of fresh plagioclase, hornblende, decomposed to chlorite and colourless epidote.

STAWELL ROCKS.—During the progress of an underground survey of the Stawell Goldfield, as originally organised by me, a number of samples of rocks were collected, principally dykes, and also samples of the granite from the Black Range. The dykes belonged to three classes—granite, quartz-porphyrites and limburgites. A short description of the mineral characters of these may prove of interest, as showing the class of eruptive rocks intersecting this auriferous area.

GRANITITE (Fine-grained grey granite).—Contains biotite, with usual inclusions, allotriomorphic quartz, perthitic and oligoclase felspars, with in places a micro-pegmatite structure. Some of the idiomorphic oligoclases show fine twinning. Secondary muscovite occurs as fine scales in some of the felspars; quartz vermiculites occur in places along the borders of the latter. It is a biotite-granite. Granite dyke (North Magdala mine) contained quartz, much pyrites, felspar, sericite, mica, green chlorite, calcite, or other carbonates, and strings of secondary quartz granules.

Dykes of granite porphyry and quartz porphyry also occur.

LIMBURGITE.—One specimen from the Amalgamated Scotchman's mine, Stawell, consists of a micro-crystalline base of partly decomposed fibres of pyroxene (augite), grains of magnetite, small altered olivines, through which are scattered phenocrysts of olivine altered to calcite and chlorite. It is a dark, close-grained rock in hand specimens. Another sample, No. 402, from Wild Cat Hill, is a

* *Vide Trans.* British Association's Glasgow meeting, 1901.

dense greenish black, heavy rock. Under the microscope, it is seen to consist of a mass of greenish chlorite, with glassy arborescent areas, black patches of ferrite, probable altered hornblende. Another slice from the Amalgamated Scotchman's is a dense black rock, seamed with pyrites. Under the microscope a micro-lamenar mass of pyrites, and clear glassy interlaminations, with distinct quartz veinlets.

SLATE.—A sample of slate from the Three Jacks mine showed "Aus veichen" strain slip, and is evidently a much broken and brecciated slate, partly silicified, full of small veinlets of quartz and black or dark strings of graphitic carbon.

It is to be regretted that owing to the ill-advised action of the Mining Department in unnecessarily suspending the survey of the Stawell field in consequence of some inaccuracies in the underground measurements, that the work of preparing a monograph on the structural geology of this important goldfield upon the basis of the complete petrographic work, has been delayed. Had I been consulted on this matter, knowing the importance of the work, the necessary corrections to the underground measurements would have been made, and the monograph on the field completed. The few slides already examined are merely a small contribution to a very important subject. The occurrence of limburgite is noteworthy.

MALDON GOLDFIELD.—During the underground survey of the Maldon goldfield by Mr. A. R. Moon, a number of samples of the eruptive and altered sedimentary rocks were collected for petrographic examination, with a view to supplementing the valuable information supplied of the structural geology of the area by Mr. Moon. Unfortunately, the abolition by the Government of the post of Government geologist, and consequent severance of my connection with the department, has prevented a complete monograph being prepared, in which the results of the petrographic research on the question of the origin and richness of the lode formations could receive adequate treatment. I have, however, sent to the department the descriptions of the slides examined, with drawings of all the more important rock species determined. This, I am informed, awaits publication, so that I can only merely refer to the names of the rocks so described, referring the members of the Geological Society to the forthcoming Mining Department publications for the technical descriptions upon which the names were based.

ERUPTIVE ROCKS. — Mt. Tarrengower granitite, muscovite-bearing aplite, quartz porphyry, norite, Lherzolite, augite andesite, limburgite, antholite (amphibolite), *omphacite*, *malacholite*, smaragdite.

ALTERED ROCKS—Calc, silicate hornfels (kalkhornfels), cordierite-bearing hornfels rock, andalusite-cordierite hornfels rock, biotite-actinolite hornfels rock, cordierite-silimanite hornfels rock, malacholite-cordierite hornfels rock, staurolite-cordierite bearing phyllite, cordierite-phyllite, cordierite-slate (knotted slate), micasite, quartzite, sandstone (but slightly altered).

MANSFIELD DISTRICT.—During a hurried visit to the then newly-discovered goldfield at Tombullip, and near Stringy-bark Creek, I collected some samples of the rocks of the locality for petrographic examination. The first was a sample of the carboniferous sandstones of Holland's Creek, of reddish colour. It was seen to consist of fairly isomerous grains of quartz and some felspar grains in a ferruginous cement. A few of the quartz granules were clear and limpid, but the greater number of grains were seen to be full of minute inclusions of dark, unresolvable spots, and some minute pinites and garnets. It may be classed as a carboniferous PSAMITE (No. 77), from Stringy-bark. This was found to consist of sub-angular to sub-rounded quartz grains, with occasional grains of a finely granular mineral substance (altered quartz), and some felspar grains. The quartz is, on the whole, clear and glassy. There is very little silicious cementing material. It is evidently a tertiary quartzite. A sample from near the contact of an eruptive rock, with the overlying carboniferous sandstones, gave some very interesting mineral features. Large irregular crystals of cordierite, spotted with enclosures of other minerals, and also large plates of a rich brown to straw yellow mineral, with pseudo-hexagonal form, also enclosing other minerals. Between these larger constituents are smaller crystals of plagioclase and flakes of biotite. The cordierites are in part altered along radial lines to yellowish decomposition products, and in places there are small groups of a dark bluish grey, to black minute crystals. Some of these, under the higher powers of the microscope, are seen to be surrounded with a border of light grey translucent mineral substance, resembling titanite, with a leucoxene border. Some of the larger brown crystals are altered in places to a talcose mineral, and to serpentenous decomposition products. Small flakes of biotite altered in places to chlorite and magnetite also occur.

The cordierite resembles in part that described from Liminlak, with the following axial colours:—(a) Dark leather brown; (b) reddish brown to honey yellow.

The plagioclase and mica would bring this rock among the eurites, but the predominance of cordierite distinguishes it from the usual types of this class of eruptives. It might *be called a* CORDIERITE eurite rock.

Another from near junction of the granitoid rocks of Tombullip, and some sandstones gave crystals of felspar and quartz, with biotite altered to chlorite and epidote, in a micro-granitic matrix. The felspar phenocrysts being in partly idiomorphic and partly allotriomorphic forms; the quartz mainly hypidiomorphic. The original biotite is nearly altered to chlorite, and granular epidote, also to magnetite. It forms in places a beautiful celyphite border round some clear garnets. In one case, the original celyphite border of biotite is almost completely altered to chlorite. The micro-granitic matrix is mostly felspar granules, with a little quartz and subordinate flecks of biotite. The rock is, therefore, a GRANITE PORPHYRY.

ELMHURST DISTRICT.—Some samples collected in the Elmhurst district during the progress of a geological survey by Mr. E. Lidgey were examined. Among these, granophyre, aplite, muscovite, granite, and diabase occurred.

One consists of allotriomorphic quartz, between which there is a granulated mosaic of quartz and felspar. The quartz crystals are much broken. Muscovite, by alteration, the felspars have acquired a micro-poecilitic structure. Some of the large crystals of plagioclase are altered to granular quartz and secondary mica. Many of the micas are altered to magnetite. The rock is a crushed aplite.

A second shows under the microscope a very distinct granitic aspect. It is composed of allotriomorphic quartz, in many cases of secondary origin, highly altered felspars, and an abundance of mica. The quartz is full of dark inclusions and shows strain shadows. The felspars, both orthoclase and plagioclase, are completely crushed or converted in aggregates of sericite. Micrographic and micropoecilitic structures have been produced. The mica is principally muscovite, although some of the forms suggest damourite. It occurs as flakes and in radial groups. Traces of biotite are observable, but mostly altered to muscovite. The whole aspect of this rock is that of a crushed muscovite granite. Small druses in parts of the slide give to the places where they occur, a miarolitic structure.

A third is made up of idiomorphic felspar in well-formed crystals, but very much altered to a micro-graphic structure, with a large amount of calcite forming broad plates. There is a little pale colourless pyroxene uratilised augite in places, and a considerable amount of chlorite. Within the areas of the latter are small rutile needles. There is very little quartz. There is much secondary mica resulting from the alteration of the felspar. The micro-graphic structures are so pronounced as to bring the rock under the class of granophyres, allied to the aplites.

A fourth is a micro-crystalline mass of partially altered

felspar, crowded with microliths of apatite, and interspersed with flakes and lath-shaped crystals of chlorite and epidote, which appear to result from the alteration of an original pyroxenic mineral, probably augite. Associated with the chlorite flakes are grains of magnetite. Traces of biotite are observed, giving the rock a kersantite aspect.

The majority of the felspars have a somewhat monoclinic habit, and, although the triclinic felspars are generally the felspathic constituents of the normal diabases, and in the absence of a twin lamellation it is sometimes difficult to distinguish the irregular grains of this mineral from small grains of clear orthoclase, yet there are sufficient indications of lamellar twinning to justify the triclinic character of some of the felspars, and to place the rock within the diabase group. It is noteworthy that in the United States certain olivine diabases having special characters are connected with the lamprophyres found in the same region.

LILYDALE.—During a rapid geological survey of an area near Lilydale, some of the rocks collected by my son, the late V. R. Stirling, were examined. Among these one example shows a fibro-granular structure. Fibrous hornblende, or actinolite, secondary quartz granules, decomposed felspars, and magnetite. It is an altered diabase.

Another is a sagenitic web of amphibole needles: magnetite, territe, oval-shaped hollows, probably where olivine has been. It is apparently an altered olivine diabase. A third is fibro-granular structure, fibrous hornblende, magnetite, decomposed felspars, needles of rutile, and secondary quartz granules. It is an altered diabase. I have classed the foregoing rocks as altered diabases, although there are certain affinities with the quartz andesites. They may be connected with the eruptive rocks of the Dandenong Ranges, which Professor Gregory has recently classed among the hypersthene bearing quartz andesites as dacites.

MT. WILLS.—During Mr. Lidgey's survey of the Mt. Wills tinfield, a few samples of the rocks of the area were collected for microscopic study. Among these I may briefly refer to the following as presenting some interesting features.

One contains microperthite, albite, and orthoclase, biotite, a little quartz, toorite—inclusions of mica and quartz in the microperthite. It is a granitite.

A second contains quartz, muscovite, brownish mineral with striations resembling hypersthene, may be a peculiar form of cassiterite—a cassiterite bearing greisen.

Another slice contained albite, muscovite, and a brownish cassiterite. It might be described as a cassiterite bearing eurite.

MT. ARARAT.—A sample examined from the mountain

gave:—Quartz (allotriomorphic) with in part small crystals of felspar. Turbid orthoclase in part idiomorphic and in parts hypidiomorphic plagioclase, scattered grains of pyrite and magnetite, biotite with characteristic inclusions and sparse hornblende.

A sample from near contact gave fine aliotriomorphic augite or hornblende, quartz granules in clusters, and along laminæ some microscopic tourmalines, a little muscovite, mica, and errite in streaks. Another sample gave quartz granules forming laminæ between very fine cryptocrystalline substance; felspar, ferrite, hornblende, and actinolite. It is a quartz hornblende schist.

BLACK FLAT.—The discovery of small veins of auriferous quartz in a decomposing dyke at Black Flat some years ago led to an official inspection of the site. I collected some samples of the less decomposed portions of the dyke for identification. One example is very much decomposed, but I was able to identify some idiomorphic felspar kaolinised or partly converted to a sericite mica, some allotriomorphic quartz, flakes of muscovite, irregular areas of calcite, traces of some ferro-magnesian mineral, probably hornblended, and magnetite; ferrite. This rock in its fresh state was probably a variety of diorite.

OBSIDIAN.—A specimen from near Coleraine. Consists of an almost clear glassy base, with a few trechites.

OTHER AUTHORS.—One of the most important of the papers which have been contributed to the Royal Society of Victoria during the past three years based upon petrographic methods of research is that on the Geology of Mt. Macedon, by Professor Gregory. In an area coloured on the geological sketch map as trap, he has identified six groups of igneous rocks. The grano-diorites of palæozoic age; hypersthene dacites (which are called from the aboriginal name of the locality geburite dacites); trachy-phonolites, solvsbergites, andesites, agglomerates and ashes. It would be impossible to do justice to this important paper in an address such as this, or to adequately discuss it in all its bearings. This I may have an opportunity of doing at an early date. En passant, I would say, that the petrographic descriptions are very clear, and whether we adopt the terms grano diorites generally, for the plutonic rocks hitherto named quartz-mica diorites; or solvsbergites for certain of the aegerine bearing svenite porphyries; or the name gebur dacites for the hypersthene bearing quartz andesites: we must recognise the valuable descriptions of the mineral structure and composition of the Mt. Macedon series of igneous rocks, which Professor Gregory has supplied. There is one reference to which I would like to draw attention. In the chapter on allied eruptive centres in Victoria, it is

stated that the Victorian rocks most closely related to the Mt. Macedon dacites are some dykes "traversing the ordovician rocks at Bendigo, originally described as limburgites, and have been referred by Mugge to the monochiquites. Now, whatever justification there may be for referring some of the Bendigo dykes to the monochique type of lamprophyres, on the examination of the dykes in the Eaglehawk mine, it is a fact that the dykes described by A. W. Howitt are undoubtedly limburgites, according to Rosenbusch's original definition. I have examined a considerable number of such dykes, both at Bendigo and in other parts of Victoria, and my determinations have been checked by several leading European petrologists. I concur with Professor Gregory's views as to the difference between the Dandenong eruptive rocks he has classed as dacites and those I have referred to as mica diorites. It is extremely probable, as suggested by Professor Gregory, that Mt. Macedon is one of the centres of volcanic eruption which took place in early cainozoic times, i.e., during the beginning of the lower eocene period. Another suggestive paper from the same author is that on the Heathcotian, which is also too valuable to be the subject of a passing reference, and which I hope to be able to refer to in some detail at another opportunity. I think that Mr. Howitt's original petrographic descriptions of the Heathcote rocks are neither improved upon, nor superseded by Professor Gregory's later work. One of the many slides examined by me from this locality belongs to the hitherto unrecognised type known as vogesite.

In an appendix to Mr. Hunter's report on the Chiltern goldfield, Professor Gregory has given short descriptions of the granitic rocks of Barambogie and Skeleton Range, as:—(1) Pegmatite, biotite, granite; (2) granophyre (an offshoot from the Barambogie granites); (3) granite porphyry dyke, intrusive to the metamorphic.

The metamorphic aureole forming flank of Skeleton Range, are described as:—(1) Altered quartz—felspathic grit; (2) alternations of granular quartzite and spotted schist and coarse grits near contact.

The ordovician as composed of (1) coarse grits of quartz-felspathic quartzite, derived from granites of Barambogie Range. The metamorphic series: (2) Altered rock showing flow structure, due to earth stresses; (3) fine-grained grey grit formed by brecciation of quartz-felsite dyke; (4) charts from glacial deposits containing radiolara, porvolosa, and sphaeroidea are also described. The conclusion is arrived at, that the granitic rocks and adjacent metamorphic series are of preordovician (the granite porphyry and granophyre being limited to the metamorphic series). The ordovician of the locality being free from igneous inclusions.

At page 7 of Mr. Hunter's report it is stated that the boundary between the metamorphic and ordovician is indefinite, but over the section shown on plan, it is stated that the metamorphic gradually change into normal slates and sandstones. Professor Gregory, however, remarks that there is no evidence of any passage from the metamorphic into the ordovician. The field observations are, therefore, at variance with the results arrived at by the petrographic examination, and require further explanation by the authors.

It is to be regretted that samples of the auriferous sandstones and slates found in the Caledonian lead were not obtained for petrographic examination, as the occurrence of both auriferous sandstones and slates are well known from various parts of the State.

In an appendix to Mr. Baragwanath's beautifully illustrated report on the Castlemaine goldfield, Professor Gregory describes some samples of the granite from near the contact with the ordovician, some metamorphosed limestones which have been crystallised by the intrusion of the Mt. Alexander granite, and also some ultra basic dykes of the limburgite type. The granite is described as altered pyroxene granite, or grano diorite, traversed by a pegmatite vein, and ordinary granite from N.E. corner of the sheet. The limestones were so much altered that no fossils were visible. The occurrence of the limburgites in the Castlemaine goldfield is highly important, as showing the extensive distribution of these igneous dykes from Bendigo southwards. I have also found these dykes at Maldon, Stawell, and in the western part of the State near Coleraine. The granite of Mt. Alexander is described as post ordovician and pre-carboniferous, thus agreeing with the view that many of the Victorian granites are probably of Devonian age, although it is extremely probable that many of the plutonic rocks of the Australian Alps which have been re-crushed so as to form banded gneisses, are of the same age as the Barambogie granite or pre-ordovician.

I have already referred to certain papers published by Messrs. Dennant and Hogg. To these I would add some interesting partly petrographic information in a paper by Mr. A. E. Kitson, on the volcanic necks at Anderson's Inlet.* I must defer a discussion of some of the points raised in this and other papers for another occasion. In the meantime it is hoped that the petrographic descriptions now supplied may help to elucidate some of the features of the mineral structure of various rock masses found in the mining and other districts of the State.

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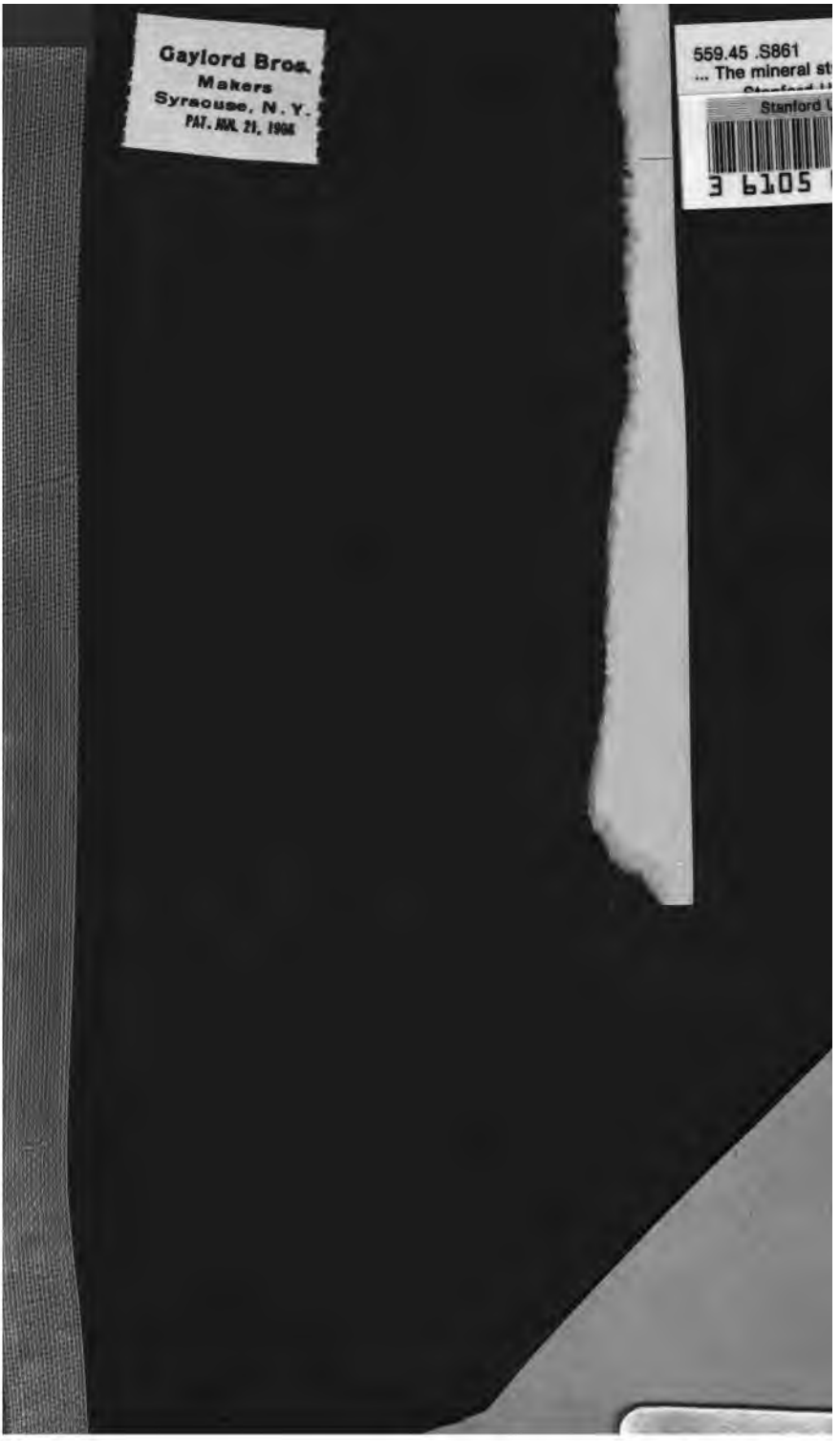
* Proceedings Royal Society of Victoria, Vol. XVI., Part I, 1903.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